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Distribution and morphology of the European Karst palpigrade *Eukoenenia gasparoi* (Arachnida: Palpigradi)

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Abstract. The first record of the palpigrade *Eukoenenia gasparoi* Condé 1988 in Croatia is reported. We review the distribution of this troglobiotic species endemic to the classical European Karst region, give an illustrated description of the adult stages and the juvenile female, and evaluate divergence among the populations. Morphological differences reflect individual-level rather than population-level variation.

Keywords: Cave, Croatia, endemism, first record, troglomorphy

Over 80% of the 28 palpigrade species recorded from Europe inhabit eaves and related subterranean habitats (Harvey 2003; Christian 2009). *Enkoenenia gasparoi* Condé 1988 belongs to a group of seven troglobiotic species characterized by at least three blades in the lateral organ and seven (exceptionally six or five) setae on the basitarsus of the last pair of legs, while the remaining European species have only one blade or four basitarsal setae. The group includes Europe's most distinctly modified cavernicolous palpigrades (Condé 1998) with consistently small distribution ranges: *E. brignolii* Condé 1979 from Apulia, Italy; *E. draco* (Peyerimhoff 1906) from Mallorca, with the subspecies *E. d. zariquieyi* (Condé 1951) from Catalonia, Spain; *E. grafittii* Condé & Heurtault 1994 from Sardinia, Italy; *E. hispanica* (Peyerimhoff 1908) from Aragon, Spain; *E. naxos* Condé 1989 from Irakleia, Greece; and *E. patrizii* (Condé 1956) from Sardinia, Italy. *Eukoenenia gasparoi* is currently the best documented member of this group and has been recorded from four localities. We report on habitat characteristics of a new location that widens the known distribution range of the species from the Classical European Karst landscapes in northeastern Italy and southwestern Slovenia toward the northwestern limits of Croatia. In order to detect possible intraspecific divergence, we supplement Condé's (1988, 1990) data with a detailed morphological description of the Croatian specimens.

METHODS

We fixed the three speeimens from the cave Radota jama in 70% EtOH, cleared them in 10% KOH and chloral phenol, and subsequently embedded them in a modification of the water soluble Swan medium (Rusek 1975). Next, we studied the slides under a Nikon E 600 mieroscope with a measuring eyepiece and phase contrast and DIC optics. Micrographs, taken with Nikon D 200 and Nikon 1 J1 cameras, were stacked and edited (contrast enhanced, motifs partly cut out) using Photoshop CS5.

Setae (in italics) are termed according to Condé (1988) except for the converse labeling of *gla* and *grt* (see footnote in Condé (1990:834). Abbreviations: B = length of propeltidium; ti = tibia; bta = basitarsus; ta = (telo)tarsus; a = maximum width of the basitarsal article (instead of the commonly used width at the insertion of seta *r*, because there the cross section of the basitarsus is not perfectly round: rotation of the article changes the apparent width); d*grt*, d*gla*, d*esp*, d*r*, d*esd* = shortest distance between the insertion of the seta and the base of the article; *fs* = forked seta(e). Indices (Table 1) are given as dividend/divisor.

The specimens are held in the eollection of the Croatian Biospeleological Society, Zagreb.

GENERAL DISTRIBUTION AND NEW RECORD OF *E. GASPAROI*

The known localities of *E. gasparoi* (Fig. 1) are situated in the western part of the Classieal European Karst, i.e., the Carso Triestino, the adjoining Low Littoral Karst, and its continuation in the karstic plateau of the Ćićarija. Although the five caves are situated along a NW–SE line no longer than 45 km, the range of distribution extends over borderlands of Italy, Slovenia, and Croatia. *Enkoenenia gasparoi* is the only endemic palpigrade species of a region where two cavernicolous congeners, *E. spelaea* (Peyerimhoff 1902) and *E. anstriaca* (Hansen 1926), have also been recorded (Zagmajster & Kováč 2006).

The locality of the first Croatian record, Radota jama (Figs. 2, 3), is an unbranched karst cave of 268 m length and 170 m depth, developed in dark brown miliolide limestone of the middle Paleocene. The entrance opens at 593 m a.s.l. on Mt. Žbevnica between the villages Rakitovec (Slovenia) and Brest (Croatia) on the Ćićarija plateau in the northern part of

Table 1.—*Eukoenenia gasparoi*, morphometric indices of all known specimens (leg I above, leg IV below the division; j = juvenile; see text for other abbreviations). New data are in bold, literature data are derived from Condé (1988, 1990). ♀1 = Grotta delle Perle, holotype; ♀2 = Grotta delle Perle, paratype; ♀3 = Grotta Azzurra di Samatorza; ♀4 = Vilenica jama; ♀5 = Radota jama; ♂1 = Vilenica jama; ♂2 = Radota jama; j♂1 = Grotta delle Perle; j♀1 = Caverna III del Monte Sedlen; j♀2 = Radota jama. * value for the opposite leg is 2.63.

	♀1	♀2	♀3	♀4	♀5	♂1	♂2	j♂1	j♀1	j♀2
bta3/*r*	1.00				**1.08**		**1.09**	0.98		**1.03**
bta3/d*r*	4.07	4.04	4.13	4.59	**4.74**	4.44	**4.32**	3.33		**4.05**
bta3/ti	0.38			0.37	**0.36**	0.37	**0.36**	0.36		**0.35**
bta3/B	0.24				**0.24**		**0.24**	0.20		**0.22**
bta/a	9.53				**8.89**		**8.89**	8.00		**8.45**
bta/*r*	2.80	2.80			**2.90**		**2.86**	2.53	2.50	**2.58**
bta/d*r*	2.42	2.42			**2.59**		**2.40**	3.44	3.15*	**3.15**
bta/ti	0.81			0.79	**0.81**	0.79	**0.77**	0.78		**0.82**
gla/grt	0.64	0.66	0.65	0.68	**0.77**	0.69	**0.71**			
bta/B	0.53	0.57	0.54		**0.55**		**0.55**	0.44	0.51	**0.51**

the Istrian peninsula, a few hundred meters within the territory of Croatia. Bat guano is a major nutrient basis for the rich cavernicolous fauna that includes the snail *Zospeum spelaeum schmidti* (Frauenfeld 1854) (Slapnik & Ozimec 2004), the spider *Mesostalita nocturna* (Roewer 1931), the pseudoscorpions *Chthonius spelaeophilus histrus* Beier 1931, *Troglochthonius doratodactylus* Helversen 1968 and *Neobisium reimoseri reimoseri* (Beier 1929), the woodlouse *Titanethes dahli* Verhoeff 1926 (Bedek et al. 2011), the centipede *Empolybothrus obrovensis* (Verhoeff 1930), the springtails *Absolonia gigantea* (Absolon 1901) and *Troglopedetes pallidus* Absolon 1907 (det. M. Lukić), the leptodirine beetle *Bathysciotes kheveuhuelleri* (Miller 1852), and the pselaphine beetle *Machaerites kastavensis* Pavićević & Ozimec 2009. For the period between November 2010 and June 2011, permanently recording instruments yielded a mean air temperature of 9.1°C (8.4–9.5) and a mean relative humidity of 99.5% (97.1–100) in the cave.

Family Eukoeneniidae Petrunkevitch 1955
Genus *Eukoenenia* Börner 1901

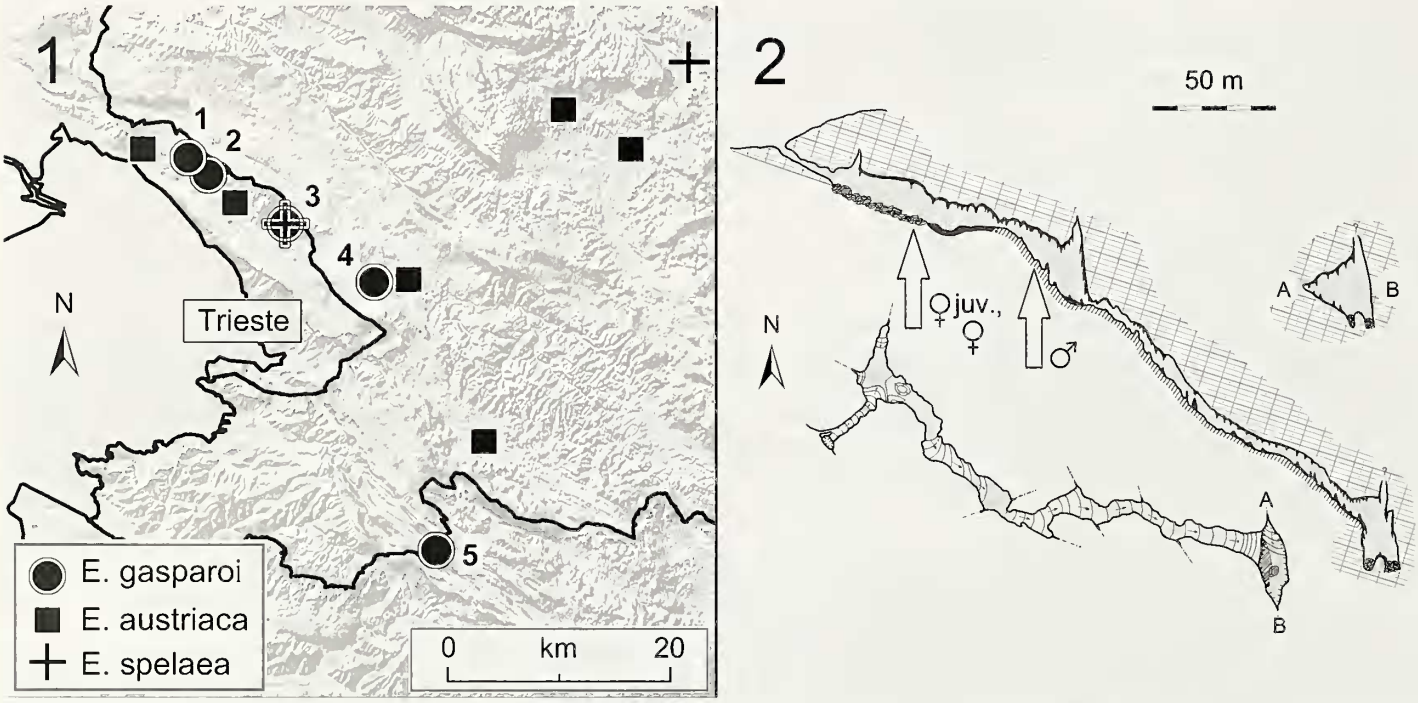
Type species.—*Koenenia mirabilis* Grassi and Calandruccio 1885, by monotypy.

Eukoenenia gasparoi Condé 1988

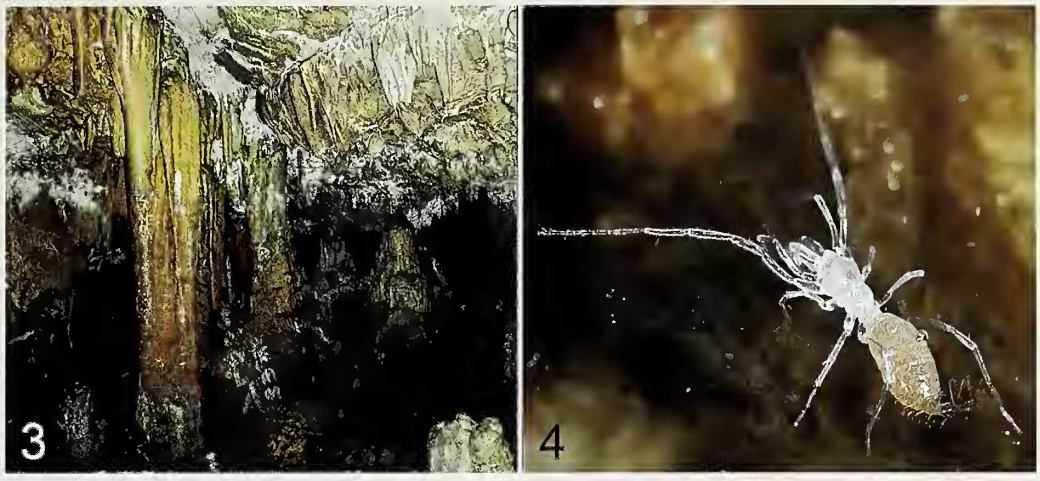
Eukoenenia gasparoi Condé 1988:729–736, Figs. 4–8, table 3; Condé 1990:833–835, Figs. 1c, 2c; Condé 1998:917, 919; Zagmajster & Kováč 2006:25, Fig. 1.

Material examined.—One adult male (leg. S. Polak) and one juvenile female (leg. V. Zakšek), collected from the underside of stones in the cave Radota jama on 27 November 2010 in the course of the Slovenian-Croatian Karst Underground Protection project (www.project-kup.org; Ozimec et al. 2011). One adult female (leg. R. Ozimec, 29 July 2001) from the same cave (Fig. 2).

Diagnosis.—A medium-sized, troglomorphic *Eukoenenia*. Adults with 3 blades in the lateral organ; 3 setal bases forming a wide V on the deuto-tritosternum; 10+10 very short setae on the propeltidium; 1+1 setae on the metapeltidium; 7 setae on the basitarsus of leg IV; tergites with only 1+1 setae *t*, flanked by one seta *s* on each side; sternites III–VI with 4+4 subequal setae; semiglobular bases of the fusules on the first genital valve of the



Figures 1,2.—Distribution and sampling maps. 1. Palpigrade records in the Classical Karst region. Overall distribution of *Eukoenenia gasparoi* as currently known: (1) Caverna III del Monte Sedlen (I); (2) Grotta Azzurra di Samatorza (I); (3) Grotta delle Perle (I); (4) Vilenica jama (SLO); (5) Radota jama (HR); data extracted from Condé (1988, 1990) and Zagmajster & Kováč (2006). 2. Radota jama (Croatia): section and plan view after Malez (1960), digitized and modified by D. Basara; arrows indicate the sampling locations of *Eukoenenia gasparoi*.



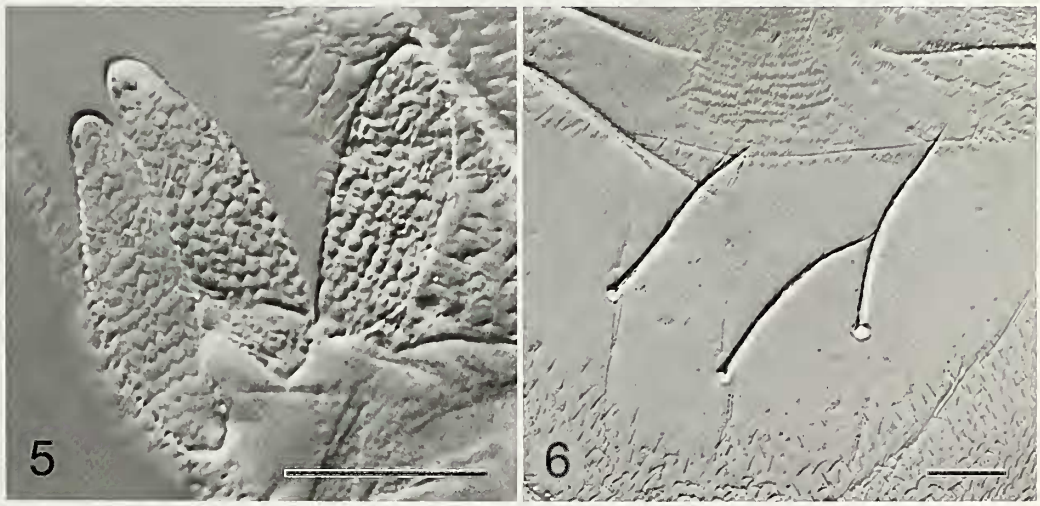
Figures 3,4.—Radota jama. 3. Habitat of *Eukoenenia gasparoi* (photo R. Ozimec). 4. *Eukoenenia gasparoi*, male, at the sampling spot in the Radota jama (photo S. Polak).

male, along with 4+4 and 5+5 setae on the following valves; 2+5+4 setae on each half of the first genital valve of the female.

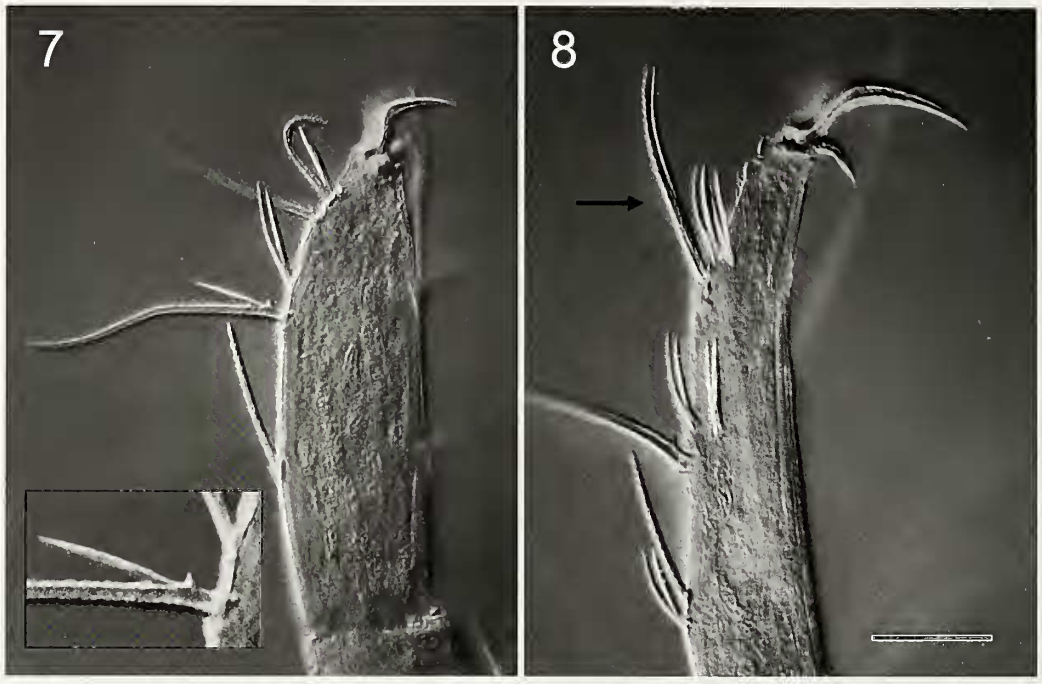
Description.—*Male:* Appearance as in Fig. 4. Body length (without the broken-off flagellum) 1560 µm. B = 440 µm. Pubescence mostly short and dense, somewhat longer and more sparse on the limbs, on opisthosomal segments IX–XI, and on labrum and deuto-tritosternum.

Frontal organ (crushed, hence overall length not determined) with a basal piece as long as the two broadly lanceolate branches, the latter abruptly narrowing to the rounded tip. The three elements of the lateral organ (37 µm) are relatively thick and evenly reticulated (Fig. 5). Propeltidium with 10+10 short setae (maximum 12 µm). Chaetotaxy of the metapeltidium reduced to 1+1 setae t_2 (76 µm). Labrum with the usual cuticular pattern and 5+5 setae (maximum 14 µm). Deuto-tritosternum with 3 subequal setae (maximum 57 µm) forming a widely obtuse angle (Fig. 6). Basal article of the chelicera with a proximal group of 6 setae (seta 4 and 6 thickened), in the distal half with 3 aligned setae (the last one longest), and 1 apical seta. Hand of the chelicera with 1 ventral and 6 dorsal setae. Fingers of the chelicera with 8 teeth.

Pedipalp in the proximal half of ta3 with a rodlike seta (23 µm) and 3 forked setae (*fs*) successively arranged in the distal half of the article (as in Fig. 7). The stiff smooth branches of the *fs* are about the same length (15–17 µm), the flexible barbed branch of the distal seta is moderately longer, that of the proximal seta considerably longer (48 µm). The proximal *fs* has, like other setae on the distal articles of the limbs, a denticle near its base. Length of pedipalp articles (µm): ti = 258, bta1 = 81, bta2 = 128, ta1 = 60, ta2 = 78, ta3 = 79. Leg I with 7 trichobothria at the usual positions and altogether 10 *fs*. The 6 *fs* of ta3 are arranged as in Fig. 8: 1 long + 2 short *fs* near the tip, followed by 1+1 and 1 short *fs* in equal distances towards the base of the article. The remaining 4 *fs* are inserted near the distal ends of ta2, bta4, bta2, and bta1; they are all long. Short *fs* (15–18 µm) are split almost down to the base; long *fs* (30–54 µm) are only furcate near the tip, but a longitudinal groove divides the shaft into a barbed and a smooth strand. The bta3 of leg I (Fig. 9) is over four times longer than wide and bears 1 short distal and 2 long setae: *grt* is a little longer than *r*, both are inserted within the proximal third of the article and surpass the base of bta4. On



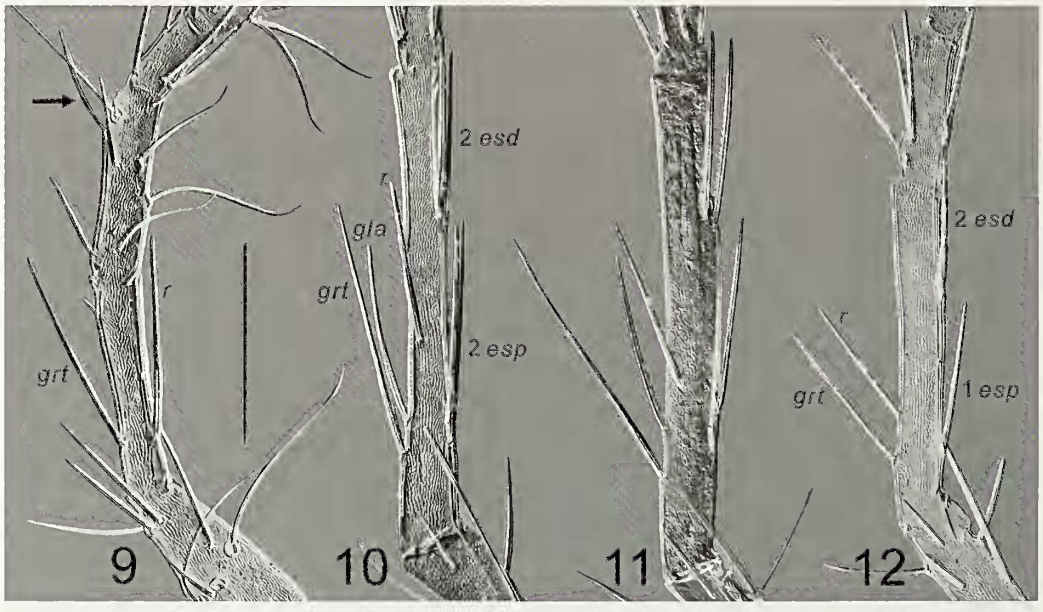
Figures 5,6.—*Eukoenenia gasparoi*, male from Radota jama: 5. Lateral organ; 6. Deuto-tritosternum. Scale = 20 µm.



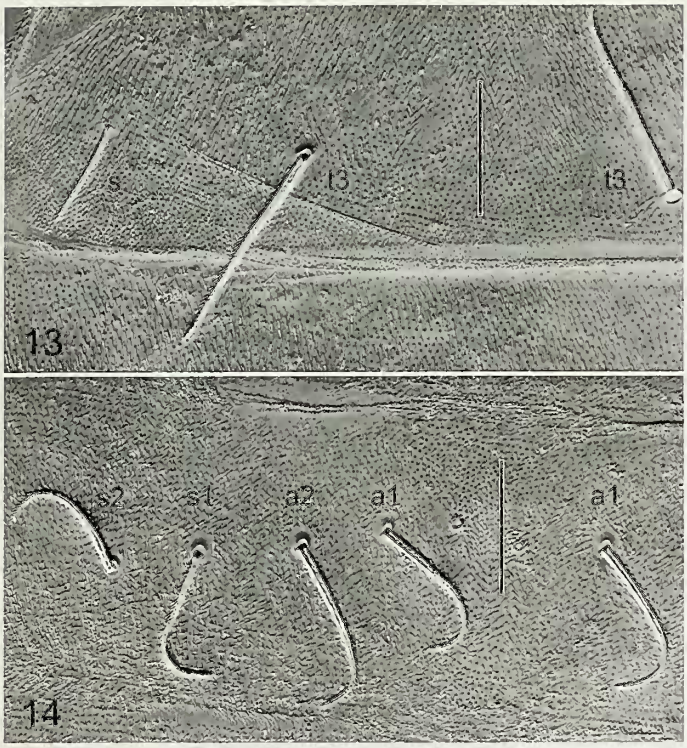
Figures 7,8.—*Eukoenenia gasparoi*, female from Radota jama, forked setae on terminal limb segments: 7. Pedipalp, ta3, with the base of the big forked seta enlarged to show the denticle ; 8. Leg I, distal half of ta3, with one long (arrow) and five short forked setae. Scale = 20 μm.

bta4, the trichobothrium, the *fs*, and 2 of the 5 ordinary setae are placed in the distal half. Measured values of leg I (μm): ti = 301, bta1+2 = 247, bta3 = 108, a = 26, *grt* = 104, d*grt* = 20, *r* = 99, d*r* = 25, bta4 = 91, ta1 = 43, ta2 = 47, ta3 = 193. Coxa of legs II and III each with 3 thickened setae (they are more cylindrical, apparently softer, and have an inclined barbule at the tip); rest of coxal chaetotaxy hardly readable. Leg IV with a very long and slender bta (nearly nine times longer than wide, Fig. 10), which bears 7 setae: *grt*, 2 *esp*, *gla*, *r* and 2 *esd*. Seta *r* is shortest, *grt* longest; all but *gla* carry a minute, oblique barbule at the tip. Measured values of leg IV (μm): ti = 310, bta = 240, a = 27, *grt* = 127, d*grt* = 50, *esp* = 109/96, d*esp* = 43/59, *gla* = 90, d*gla* = 67, *r* = 84, d*r* = 100, *esd* = 87/89, d*esd* = 152/158, ta1 = 84, ta2 = 96. Indices of leg I: bta3/a = 4.15, bta3/*r* = 1.09, bta3/d*r* = 4.32, bta3/ti = 0.36, bta3/B = 0.24. Indices of leg IV: bta/a = 8.89, bta/*r* = 2.86, bta/d*r* = 2.40, bta/ti = 0.77, bta/B = 0.55.

The opisthosoma shows a sudden narrowing between segments VIII and IX. Tergites II–VI with one seta *t* (probably t_3) and one seta *s*. Tergal setae *s* are considerably shorter than *t*, more slender and lack a typical basal ring (Fig. 13). Sternite III with st_2 and st_3. Sternites III–VI each with a pair of sternal



Figures 9–12.—*Eukoenenia gasparoi* from Radota jama: 9. Male, leg I, basitarsus 3 and 4, the arrow points to the forked seta next to the trichobothrium of basitarsus 4; 10. Male, leg IV, basitarsus; 11. Female, leg IV, basitarsus; 12. Juvenile female, leg IV, basitarsus. Scale = 100 μm.



Figures 13,14.—*Eukoenenia gasparoi*, male from Radota jama, opisthosomal chaetotaxy: 13. Tergite III; 14. Sternite IV. Scale = plane of symmetry = 50 μm.

pores and the setae a_1, a_2, s_1 and s_2 (Fig. 14), in the terminology of Condé (1988). The four setae of each hemisternum are of similar length, identical structure, and inserted at equal distances, so that they might as well be interpreted as a_{1-4}. On sternite VI, the setae a_1 are 66 μm long and 77 μm apart. Segments VII–XI with 7, 9, 8, 8, and 8 (maximum 101 μm) setae. The flagellum is lost.

Shape of the first genital lobe (Fig. 15) uncertain due to folding. It probably conforms to Fig. 8 in Condé (1988), just as the setation does. 2+2 sternal setae (st_1, st_2) are followed, on the lobe in the proper sense, by 11+11 phaneres including 2+2 fusules. Each fusule is inserted on top of a glabrous hemisphere through which the efferent duct shines (Fig. 16). The two flaps of the second lobe each with 4, those of the third lobe each with 5 setae (Fig. 15).

Female: Complementary observations (characters conform with those of the male partly omitted). Body length (without the broken-off flagellum) 1590 μm. B = 450 μm. Blades of the lateral organ maximum 35 μm. Seta t_2 on the metapeltidium 89 μm. Deuto-tritosternal setae maximum 58 μm. Pedipalp on ta3 with a rodlike seta and 3 *fs* (Fig. 7) arranged and shaped just as in the male. Length of pedipalp articles (μm): ti = 252, bta1 = 97, bta2 = 129, ta1 = 59, ta2 = 79, ta3 = 84. Coxa of the pedipalp with 19 setae, coxae of legs I–IV with 15 (0 thickened) / 14 (3 thickened; Fig. 17) / 12 (3 thickened) / 8 (0 thickened) setae. Leg I with trichobothria and *fs* as in the male (Fig. 8), shape and chaetotaxy of bta3 and bta4 the same. Measured values of leg I (μm): ti = 301, bta1+2 = 247, bta3 = 109, a = 27, *grt* = 108, d*grt* = 18, *r* = 101, d*r* = 23, bta4 = 98, ta1 = 48, ta2 = 53, ta3 = 199. The proportions of the basitarsus of leg IV are almost the same as in the male, but the insertions of the setae (particularly *gla* and *r*) differ (Fig. 11). Measured values of leg IV (μm): ti = 309, bta = 249, a = 28, *grt* = 126, d*grt* = 59, *esp* = 106/107, d*esp* = 65/74, *gla* = 97, d*gla* = 76, *r* = 86, d*r* = 96, *esd* = 91/95, d*esd* = 172/174, ta1 = 82, ta2 = 96. Indices of leg I: bta3/a = 4.04, bta3/*r* = 1.08, bta3/d*r* = 4.74, bta3/ti = 0.36, bta3/B = 0.24. Indices of leg IV: bta/a = 8.89, bta/*r* = 2.90, bta/d*r* = 2.59, bta/ti = 0.81, bta/B = 0.55. Setation of the opisthosomal segments II–VI as in the male. On sternite VI the setae a_1 are 73 μm long and 64 μm apart. Segments VII–XI with 7, 9, 8, 8, and 8 (maximum 120 μm) setae.

First genital lobe with 22 setae, each half has 2 basal + 5 + 4 apical. The basal setae are longest (maximum 75 μm), the apical seta a_4, inserted somewhat above a_{1-3}, is 35 μm long (Fig. 18). The two flaps of the second genital lobe each with 3 setae.

Juvenile female: Body length (without the broken-off flagellum) 1440 μm. B = 365 μm. Frontal organ (39 μm) shaped as in the adult ♂. Lateral organ (Fig. 19) with two blades (31 μm). Labrum with 4+4 setae. Deuto-tritosternum (Fig. 20) with 1 seta (47 μm). Chelicera with complete setation, fingers with 7 teeth.

Length of pedipalp articles (μm): ti = 193, bta1 = 68, bta2 = 105, ta1 = 53, ta2 = 69, ta3 = 71. Propeltidium with 11+11 short setae (i.e., with one pair more than the adult ♂). Metapeltidium with 1+1 setae (74 μm). Legs with trichobothria, *fs*, and thickened coxal setae as in the adult. Measured values of leg I (μm): ti = 230, bta1+2 = 171, bta3 = 81, a = 24, *grt* = 81, d*grt* = 11, *r* = 79, d*r* = 20, bta4 = 76, ta1 = 42, ta2 = 42, ta3 = 170. Basitarsus of leg IV (Fig. 12) with incomplete setation (*gla* and 1 *esp* missing). Measured values of leg IV (μm): ti = 227, bta = 186, a = 22, *grt* = 89, d*grt* = 35, *esp* = 82, d*esp* = 26, *r* = 72, d*r* = 59, *esd* = 77/74, d*esd* = 111/110, ta1 = 74, ta2 = 86. Indices of leg I: bta3/a = 3.38, bta3/*r* = 1.03, bta3/d*r* = 4.05, bta3/ti = 0.35, bta3/B = 0.22. Indices of leg IV: bta/a = 8.45, bta/*r* = 2.58, bta/d*r* = 3.15, bta/ti = 0.82, bta/B = 0.51.

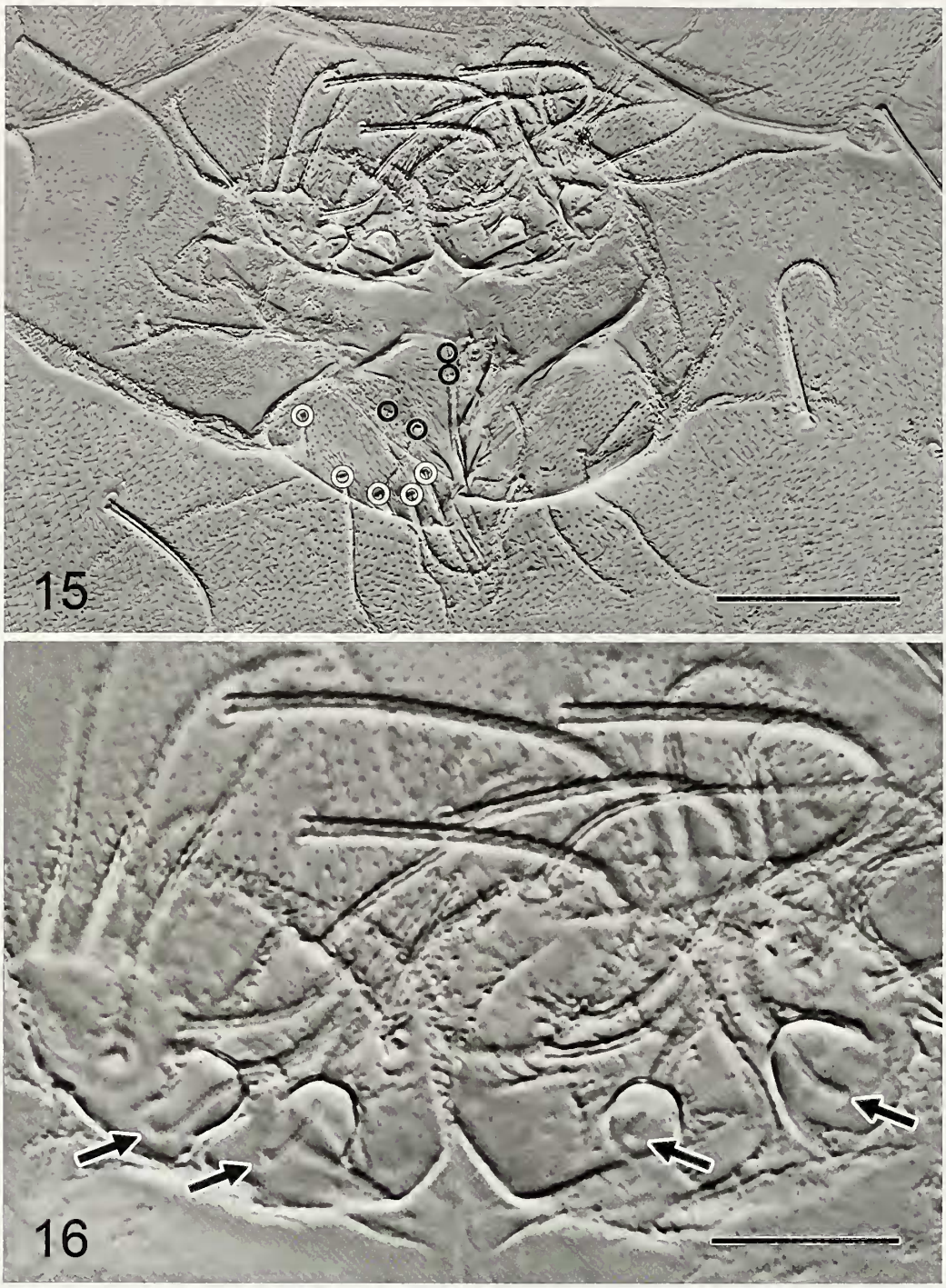
Primordia of genital valves are developed on opisthosomal segments II and III (Fig. 21). On the unpaired, but mediodistally cleft anterior valve of the juvenile ♀ 4+4 long and 2+1 minute subapical setae; the longest, most anterior pair (51 μm) probably represents 1+1 st_1. The posterior valve is composed of two lobes, each with 1 short seta. Two long setae at either side of the posterior valve are the sternal setae of segment III, st_2 and st_3.

Chaetotaxy of tergites II–VI as in the adult. Sternites IV–VI with a_1, a_2, and s_1; setae s_2 are missing (Fig. 22). On sternite VI, the setae a_1 are 61 μm long and 79 μm apart. All gland orifices are visible. Segment VII with 7, XI with 8 setae (chaetotaxy of VIII–X unclear).

Variability.—Table 1 compiles all available indices of the presently known specimens. The values lie closely together, suggesting that there has been virtually no morphological divergence among the Italian, Slovenian, and Croatian populations of *E. gasparoi*.

DISCUSSION

Cavernicolous palpigrades differ in morphological characteristics thought to be influenced by the subterranean environment; some species appear more troglomorphic, while others appear less so (sensu Christiansen 1962). Although



Figures 15,16.—*Eukoenenia gasparoi*, male from Radota jama: 15. Total aspect of the genital valves; black rings indicate setal bases of the second valve, white rings those of the third valve. Scale = 50 μm; 16. First genital valve. Arrows point at the hemispheric bases of the fusules. Scale = 20 μm.

Eukoenenia gasparoi has a moderately long flagellum of 1.30 times the body length (Condé 1990) and a common number of blades in the lateral organ, the elongated ambulatory and sensory limbs immediately suggest troglomorphy. This impression is supported by indicator indices such as the basitarsus IV proportion. Condé (1998) reports length/width values between 3.22 and 10.22 for cave-dwelling palpigrades, with *E. gasparoi* (9.53, holotype) ranking among the most troglomorphic species. In specimens from Radota jama, this ratio is 8.89 (♂ and ♀) and 8.45 (juv. ♀). According to Condé (1996), the length ratio basitarsus IV/propeltidium separates soil from cave palpigrades, averaging 0.28 in the former and 0.59 in the latter. Again the Croatian specimens turn out to be troglomorphic: 0.55 (♂ and ♀) and 0.51 (juv. ♀). The two indices suggest increasing troglomorphism from the juvenile to the adult stage, and so does the length of the foreleg. It is about 1.30 the body length in the adult specimens from Radota jama, but just 1.07 in the juvenile female.

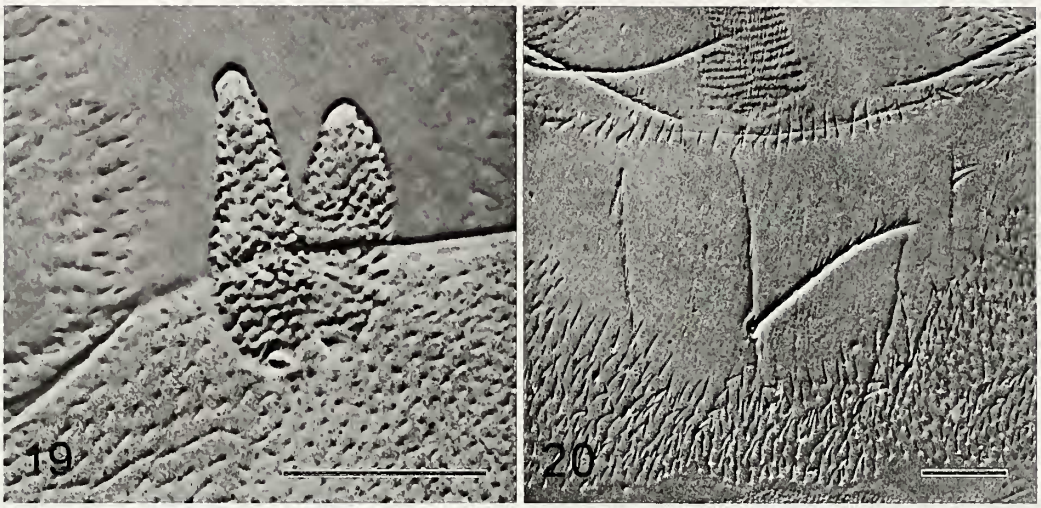
Figure 17.—*Eukoenenia gasparoi*, female from Radota jama, coxa of leg II; circles indicate the insertions of the thickened setae. Scale = 50 μm.

Figure 18.—*Eukoenenia gasparoi*, female from Radota jama, first genital valve; the dotted line indicates the plane of symmetry. Scale = 20 μm.

The length of basitarsus IV in relation to the tibia has also been considered informative for the degree of cave adaptation. Condé (1990) established bta/ti values of 0.70–1.00 for most of the cavernicolous palpigrades and 1.10 for the extremely troglomorphic *E. naxos*. Souza & Ferreira (2010) determined a bta/ti value of 1.07 for *E. maquinensis* from Brazil, a troglobiotic species with an excessively long flagellum. In *E. gasparoi*, however, the basitarsus of leg IV is clearly shorter than the tibia (bta/ti between and 0.77 and 0.82), suggesting moderate troglomorphy. The apparent inconsistency between bta/B and bta/ti leads us to conclude that any index, taken individually, may be an unreliable indicator of palpigrade troglomorphy. A long basitarsus may be caused either by an elongation of this very structure, or of the entire leg, or both. Furthermore, the comparison among related species shows that morphological changes in response to subterranean life do not necessarily evolve at the same pace, if they evolve in parallel at all. Many troglobiotic animals, cave fishes included, display a mosaic of more or less troglomorphic traits (Romero 2011). In *E. naxos*, for instance, all relevant characters indicate "most advanced subterranean evolution", except the number of blades in the lateral organ (Condé 1990).

The vast majority of the 27 native European plus one introduced palpigrade species occur in caves (Christian 2009), but only six resemble *E. gasparoi* in regard to btaIV chaetotaxy. None of them has more than two setae *t* on the tergites III–VI, and two species (*E. naxos*, *E. patrizii*) share with *E. gasparoi* the reduction to a single seta *t*. Number, distribution, and shape of the forked setae on the distal articles of pedipalp and leg I separate *E. gasparoi* from the species of the *mirabilis*, *spelaea,* and *subangusta* complexes, but it remains unclear whether this is a shared character state of all the seven species with an elevated number of setae on btaIV. These definitely troglobiotic palpigrades, supposed descendants from an ancient tropical fauna (Condé 1998), are probably endemic to closely confined areas. Some have been recorded solely from the type locality, but considering the mostly accidental records of palpigrades in caves, one need not necessarily presume spot endemism. *Eukoenenia gasparoi* surpasses related species in the density of records, so that the area of distribution is taking shape. The record reported here expands the known range from the Classical European Karst in the hinterland of Trieste (Italy) and Divača (Slovenia) some 30 km to the southeast, by a small distance into Croatian territory. Two other, closely related palpigrade species, *E. spelaea* and *E. austriaca*, partly overlap the range of *E. gasparoi*, but have much wider distributions. *Eukoenenia gasparoi*, however, is endemic to the area traditionally called "the Karst"; it is the Karst palpigrade par excellence. Intensified biospeleological research might uncover occurrences of *E. gasparoi* in other caves of the Ćićarija and the heartland of Istria, but the species is obviously missing in the well-investigated Postojna and Kočevje regions. We do not know of any current threat to *E. gasparoi*, but the small area of distribution makes the species appear vulnerable. The maintainance of the populations lies in the responsibility of the three countries.

The specimens from Radota jama consolidate the key characteristics of *E. gasparoi* and make adults easily determined. Inspection of the deuto-tritosternum alone would be sufficient for identification, as the reduced chaetotaxy (three setal bases forming a wide V in adult specimens) is unique among European palpigrades. Consideration of additional



Figures 19,20.—*Eukoenenia gasparoi*, juvenile female from Radota jama: 19. Lateral organ; 20. Deuto-tritosternum. Scale = 20 μm.

Figures 21,22.—*Eukoenenia gasparoi*, juvenile female from Radota jama: 21. Genital valves, black rings indicate the bases of the minute distal setae of the first valve; 22. Chaetotaxy of the opisthosomal sternite IV. Scale = plane of symmetry = 50 μm.

characters (see Diagnosis) resolves all doubt about species affiliation.

Eukoenenia gasparoi appears to be morphologically uniform. Although existing descriptions (Condé 1988, 1990) give no information on the propeltidial chaetotaxy of juvenile specimens, we assume that the additional pair of setae on the propeltidium of the juvenile female from Radota jama is due to individual variation. The same applies to the unstable insertion height of certain setae of basitarsus IV (compare Figs. 10 and 11). As even the left and the right basitarsus of one individual can differ (e.g., asterisk in Table 1), we follow Condé (1988, 1990) in regarding this variation as taxonomically irrelevant.

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LITERATURE CITED

Bedek, J., S. Taiti & S. Gottstein. 2011. Catalogue and atlas of cave-dwelling terrestrial isopods (Crustacea: Oniscidea) from Croatia. Natura Croatica 20:237–354.

Christian, E. 2009. A new soil-dwelling palpigrade species from Northern Italy (Palpigradi: Eukoeneniidae). Zootaxa 2136:59–68.

Christiansen, K. 1962. Proposition pour la classification des animaux cavernicoles. Spelunca 2:76–78.

Condé, B. 1988. Nouveaux Palpigrades de Trieste, de Slovénie, de Malte, du Paraguay, de Thaïlande et de Borneo. Revue Suisse de Zoologie 95:723–750.

Condé, B. 1990. Palpigrades (Arachnida) de grottes d'Europe. Revue Suisse de Zoologie 96:823–840.

Condé, B. 1996. Les Palpigrades, 1885–1995: acquisitions et lacunes. Revue Suisse de Zoologie, volume hors série, 87–106.

Condé, B. 1998. Palpigradida. Pp. 913–920. *In* Encyclopaedia Biospeologica, vol. 2. (C. Juberthie & V. Decu, eds.). Société de Biospéologie, Moulis, Bucharest.

Harvey, M.S. 2003. Catalogue of the smaller arachnid orders of the world. CSIRO Publishing, Collingwood, Australia.

Malez, M. 1960. Pećine Čičarije i Učke u Istri. Acta Geologica 2:164–260.

Ozimec, R., S. Polak, J. Bedek & V. Zakšek. 2011. Importance of biospeleological research for protection of cave fauna and their habitats – example based on the project Karst underground protection on the Istrian peninsula. Pp. 160–168. *In* Pressures and Protection of the Underground Karst – Cases from Slovenia and Croatia. (M. Prelovšek & N. Zupan Hajna, eds.). Karst Research Institute, Postojna.

Romero, A. 2011. The evolution of cave life. American Scientist 99:144–151.

Rusek, J. 1975. Eine Präparationstechnik für Springschwänze und ähnliche Gliederfüsser. Mikrokosmos 12:376–381.

Slapnik, R. & R. Ozimec. 2004. Distribution of the genus *Zospeum* Bourguignat 1856 (Gastropoda, Pulmonata, Ellobidae) in Croatia. Natura Croatica 13:115–135.

Souza, M.F.V.R. & R.L. Ferreira. 2010. *Eukoenenia* (Palpigradi: Eukoeneniidae) in Brazilian caves with the first troglobiotic palpigrade from South America. Journal of Arachnology 38:415–424.

Zagmajster, M. & L. Kováč. 2006. Distribution of palpigrades (Arachnida, Palpigradi) in Slovenia with a new record of *Eukoenenia austriaca* (Hansen, 1926). Natura Sloveniae 8:23–31.

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